SUMMARY

The calcium requirement of Single Comb White Leghorn chicks fed a purified diet containing no phytate was 0.5%. This requirement was increased to 0.95% by feeding a diet composed of natural ingredients and containing 1.25% phytic acid or phytate. Hydrolysis of 90% of the phytic acid with phytase reduced the amount of calcium needed in the natural ingredient diet by a least one-third.

The level of calcium in diets of growing chicks must compensate for that which is inactivated by phytate. The apparent calcium requirement will vary as the phytate concentration varies in the diet ingredients.

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The Effect of Level of Skin on the Quality of Chicken Frankfurters

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INTRODUCTION

IN RECENT years the depreciation of the hen has become the second largest cost of producing a dozen eggs, second only to feed costs. In order to increase the demand for fowl and thus increase the price the poultryman receives for them, new uses for the meat must be found through further processing. With this aim in view, several companies are exploring the feasibility of using chicken meat in some of the same ways that the red meats are used, in sausage or emulsion products, for example.

It has been the authors' experience that

regardless of the protein-water-fat ratio, one seldom finds a frankfurter made from chicken alone which has the same texture as a good red meat frankfurter. One of the principal ways in which chicken meat differs from beef, pork and lamb is that the skin is generally considered an integral part of the meat, while with red meats this is not the case. This skin, as the skin of other animals, contains substantial amounts of collagen which under certain conditions is known to break down to form gelatin. The effect of skin on the texture of a frankfurter, whether it be made of red meat or chicken, cannot be found in the literature. Saffle *et al.* (1964) investigated the effect of the addition of collagen (in the form of pork skins) on the peeling ease of franks, but made no mention of its effect on their texture. Simon *et al.* (1965) and Swift and Weir (1954) investigated the effect of various levels of fat, protein and water, and of various processing equipment and procedures, on the texture of franks and bologna, but did not include the effect of collagen.

This study was undertaken to determine the effect of skin added at various levels on the texture (including tenderness) and juiciness, of frankfurters made from chicken.

MATERIALS AND METHODS

Formulation and Processing. Fresh fryers were obtained from a nearby processing plant, skinned and deboned by hand, then frozen at −25°C. and held at that temperature until used, the skin and meat being packaged separately. Chicken fat, from fowl, was obtained frozen from the same plant and held at −25°C. until used.

In order to obtain batches with approximately the same composition, representative samples of the raw materials (meat and skin) for each run were analyzed for fat and moisture. The fat method was that of Salwin *et al.* (1955) modified by the use of sulfuric acid and water instead of acetic acid and perchloric acid. Moisture was determined by an Ohaus Moisture Determination Balance. Ten gram samples were dried on the balance at approximately 143°C. for 30 minutes. Protein was calculated by difference (less one percent for ash). Using these figures, the amount of fat and ice to be added was calculated according to the following procedure:

1. $$\frac{M_p \times \text{wt. of meat}}{100} + \frac{S_p \times \text{wt. of skin}}{100} = T_p$$

2. $$T_p \div \frac{B_p}{100} = \text{TBW}$$

3. $$\frac{B_f \times \text{TBW}}{100} - \frac{S_f \times \text{wt. of skin}}{100} - \frac{M_f \times \text{wt. of meat}}{100} = \text{weight of fat to add}$$

4. $$\frac{B_w \times \text{TBW}}{100} + \frac{\text{TBW} \times SS}{100} - \frac{S_w \times \text{wt. of skin}}{100} - \frac{M_w \times \text{wt. of meat}}{100} = \text{weight of water (in the form of ice) to add}$$

Where:

M_p = % protein in meat
S_p = % protein in skin
B_p = % protein in finished batch
T_p = Total amount of protein in finished batch
M_f = % fat in meat
S_f = % fat in skin
B_f = % fat in finished batch
M_w = % water in meat
S_w = % water in skin
B_w = % water in finished batch
TBW = Total batch weight
SS = % allowance for smokehouse shrink (predetermined)

The meat and skin were ground separately through a 0.31 cm. plate and each lot was mixed well before being weighed. The fat was cut into one-half inch cubes. Following customary processing procedures, the frankfurter emulsion was chopped in a Model FD632/4D Schnellcut-

ter, all lots being chopped to 12°C. After being stuffed into #23 Visking Nojax frankfurter casings and linked, the frankfurters were cooked in a smokehouse (with no smoke) according to the following schedule: 54°C. for 30 minutes, 63°C. for 30 minutes, 71°C. for 30 minutes and 77°C. for 15 minutes.

The frankfurters were then water cooked (at 74°C.) to an internal temperature of 68°C. cold showered and refrigerated at 2°C. until the following morning. They were then peeled and held at 2°C. in sealed plastic bags until used for testing.

In this manner, batches were made for Series 1, with skin added at the rate of 0, 5 and 15 percent, for Series 2, at 0, 10 and 20 percent and for Series 3, at 0, 30, 40, and 50 percent of the meat and fat component of the batches. Salt and seasoning were added in proportion to the meat, skin and fat. Each experiment was duplicated the following week.

Testing. All testing was done both on cold and on heated samples (except the puncture test) in order to determine the effect, if any, of heating on the skin component of the formula.

Tenderness. Tenderness was determined using an Allo-Kramer Shear Press Model S2HE with the standard shear cell. For each of three determinations, five frankfurters were cut to 6.5 × 1.3 × 1.3 cm., which filled the cell when inserted at right angles to the slots. Each set of five samples was weighed to the nearest 0.1 gram, inserted and sheared, using a 25 second downstroke. Pounds of force per gram required to shear was calculated by using the following formula:

$$\frac{\text{Total force in pounds}}{\text{sample weight in grams}} = \text{pounds of force per gram}$$

Samples were also sheared hot by cutting to the above dimensions, wrapping each set in aluminum foil, sealing three sets per lot in a boilable plastic bag and heating for 15 minutes in boiling water. The sets were then unwrapped, one at a time, weighed and rapidly sheared while still hot.

Juiciness. Percent of fluid expressed, as an indication of juiciness, was determined by cutting 10 two gram samples (±0.05 grams) with the "skin" removed, weighing to the nearest .01 gram, and pressing between two felt discs on a Carver Laboratory Model Press using 400 pounds pressure for two minutes. The sample was then reweighed and the percent of fluid expressed was determined using the following formula:

$$\frac{\text{weight of sample before} - \text{weight of sample after}}{\text{weight of sample before pressing}} \times 100 = \% \text{ expressible fluid}$$

Ten determinations were made for each lot using unheated frankfurters and 10 using samples that had been heated by boiling for 15 minutes in a sealed boilable plastic bag then cooling to room temperature.

Puncture Test. Twenty-five halved frankfurters were cut in two pieces longitudinally. Each half was punched twice with a circular flat faced punch with an area of one sq. cm. The force required to obtain the bioyield point (a point of permanent and irreversible deformation, represented by a sudden change in slope of the line) was recorded using an Instron Universal Testing Machine. The crosshead speed was 20 cm. per minute.

Deformation Tests. Cold. Cross-sections two cm. long were cut from the 25 halves of frankfurters remaining from the puncture tests. From each cross-section a cylinder was cut 1.5 cm. in diameter with a power driven cork borer. Deformation was measured, using an Instron Universal Testing Machine, between a five and 25 gram load, with the sample placed with the long axis horizontally. Actual deformation was

computed as follows:

$$\frac{\text{Recorded deformation}}{50} = \text{actual deformation}$$

The Instron settings were as follows: crosshead speed = 1 cm./min., chart speed = 50 cm./min., full scale load = 100 grams.

Deformation Tests. Hot. Sample preparation was the same as for the cold deformation test except that 16 halves were used. After the cylinders were cut out, they were replaced in the shells, and four pieces at a time were heated in a boilable plastic bag, in boiling water for 15 minutes, with a weight to keep the samples immersed. The samples were removed from the bag one at a time for testing, and tested as rapidly as possible to minimize cooling. Computations and Instron settings were the same as for the cold deformation testing.

Taste Paneling. Eight experienced and pre-trained judges scored samples both cold and heated (by sealing in boilable plastic bags and boiling for 15 minutes) for tenderness, juiciness and chew count. A nine point scale was used for tenderness and juiciness, the higher scores indicating more tender and more juicy. A separate two gram sample (± 0.1 grams) was used for chew count determinations. The "skin" or outer proteinacious layer of all frankfurters was removed before presentation to the panel. Judging was done in individual booths in an air conditioned room with controlled lighting and all testing was done in duplicate.

Analysis of Data. Analysis of variance and correlation coefficients were obtained with the aid of a Control Data 1604 Computer, and Duncan's new multiple range test, calculated by the method of Steel and Torrie (1960), was used for the significance of treatment means.

RESULTS AND DISCUSSION

Tenderness. In series 1 there was a significant difference in the tenderness of the frankfurters, as judged by the taste panel, between 0 added skin and 15 percent (Table 1). Series 2, however, using 0, 10 and 20 percent added skin, showed no significant difference. Series 3, using 30, 40 and 50 percent added skin, did show a significant difference between 0 and all the higher levels when tested both cold and hot. In all cases, the higher levels of skin were firmer.

Kramer Shear Press values (see Table 2) tested cold showed significant differences between 0 and 15 percent in series 1, no difference in series 2, and between 0 and 30, and 30 and 40 percent in series 3. When tested hot there were significant differences between 0 and 5 percent (series 1), and 0 and 10 percent (series 2) and each level in series 3, the higher levels showing higher values which indicates in-

TABLE 1.—*Effect of added skin on chicken frankfurters (taste panel scores)*

Level of Skin %	Tenderness		Juiciness		Chew count	
	Cold	Hot	Cold	Hot	Cold	Hot
Series 1						
0	6.15	6.31	5.69	6.31	13.72	13.50
5	6.00	6.03	5.22	5.88	13.44	13.78
15	5.31	5.50	4.91	5.47	13.59	14.09
Series 2						
0	5.28	5.75	4.84	6.17	14.19	13.97
10	5.34	5.97	4.81	5.35	14.19	13.72
20	5.13	5.72	4.78	5.94	13.53	14.09
Series 3						
0	6.09	6.31	4.88	5.81	13.94	13.97
30	4.94	5.53	4.53	5.34	14.94	16.56
40	4.94	5.38	4.63	5.50	14.97	15.05
50	4.31	5.16	4.19	5.16	15.31	15.19

Tenderness was judged on a 9 point scale from 9 (too tender, mushy) to 1 (very firm), juiciness on a 9 point scale from 9 (wet) to 1 (very dry). Chew count was the number of chews required to chew a 2 gram sample before swallowing.

Means connected by the same line are not significantly different from each other ($P < .05$).

TABLE 2.—*Effect of added skin on chicken frankfurters (objective tests)*

Level of skin %	Shear Press Values (1)		Puncture test (2)	Deformation test (3)		Expressible fluid (4)	
	Cold	Hot	Cold	Cold	Hot	Cold	Hot
				Series 1			
0	0.85	0.89	0.964	0.078	0.105	16.00	19.29
5	0.96	1.07	0.946	0.067	0.106	16.00	17.49
15	1.08	1.08	1.058	0.069	0.096	18.20	17.56
				Series 2			
0	1.23	1.09	1.132	0.049	0.109	12.61	13.32
10	1.30	1.17	1.131	0.053	0.101	11.36	14.46
20	1.30	1.19	1.207	0.058	0.104	12.41	14.91
				Series 3			
0	1.17	1.09	1.19	0.052	0.111	11.69	11.79
30	1.37	1.37	1.28	0.061	0.106	13.05	12.56
40	1.42	1.54	1.25	0.061	0.099	14.03	14.85
50	1.43	1.43	1.26	0.066	0.098	14.81	16.82

(1) Pounds of force per gram of sample required to shear.
(2) Force in kilograms required to obtain the bioyield point.
(3) Amount of deformation between a 5 and 25 gram load, in centimeters.
(4) Percent free fluid expressed from sample.
Means connected by the same line are not significantly different from each other ($P<.05$).

creased toughness. The Instron puncture test showed the same trend as the panel scores for tenderness and shear press values with significant differences between 5 and 15 percent (series 1), and 10 and 20 percent (series 2) and 0 and the higher levels (series 3). The three series were also subjected to analysis of variance as a whole, and the same trend was evident, the point at which most differences between levels appear being between 20 and 30 percent added skin.

Correlations (See Table 3) run on subjective and objective tests for tenderness and percent skin show highly significant correlations between skin levels and both taste panel tenderness scores (cold, $r = -.841$; hot, $r = -.744$) and shear press value (cold, $r = .754$; hot, $r = .854$). A significant correlation existed between skin level and the puncture test ($r = .565$). From the results of the cold and hot deformation tests, there appears to be significant differences between levels of skin. Even though deformation tests on foods are used as a measurement of softness—hardness (Bourne, 1967), these differences appear to be unrelated to the skin level of the frankfurters, since the correlations (see Table 3) between skin level and the cold and hot deformation tests are $r = -.360$ and $r = -.005$, respectively. Chew count also seems to be of little value in assessing the tenderness of frankfurters (Table 1).

These results all indicate an increase in toughness or firmness in the frankfurters as more skin is included in the formula. According to Watt and Merrill (1963), fryer skin contains 16.1 percent protein, of which 8.6 percent is collagen (Maurer, 1968), or more than 53 percent of the total protein. According to Bendall (1946), as collagen is heated, the fibers shrink, and the triple helices of the molecule unravel, giving polypeptide chains in which random motion is possible, therefore becoming rubberlike and offering considerable resistance to chewing. Further heating will generally break down the collagen into a gelatin sol, but at 100°C., this will take an extremely

TABLE 3.—*Correlation coefficients*

	Tenderness		Juiciness		Chew count		Shear Press		Express. Fluid		Puncture test	Deformation	
	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Cold	Hot
Percent Skin	−.841**	−.744**	−.755**	−.614**	.489*	.650**	.754**	.854**	−.005	.077	.565*	.263	−.360
Subjective tests													
Tenderness—cold			.730**		−.572*		−.773**		.092		−.665**	−.122	
—hot				.827**		−.722**		−.596*		−.064			.557*
Juiciness—cold					−.333		−.699**		.261		−.691**	.080	.448
—hot						−.394		−.510*		.117			
Objective tests													
Shear Press—cold									−.377		.754**	−.274	
—hot										−.216			−.128
Puncture test—cold									−.518*			−.480	

* Significant at the 5% level.
** Significant at the 1% level.

long time (Hamm, 1960). The amount of heat involved in the processing and heating for serving of the frankfurters in this study appears to be sufficient to produce the shrinking and toughening of the collagen fibers, but not long enough nor high enough to produce solubilization.

Although the frankfurters with higher levels of skin were firmer than those with lower levels, (firmness in a frankfurter is generally to be desired) the firmness created by added skin was caused, at least in part, by small chewy skin particles which were visible at the cut surface of a frankfurter. This condition was considered as somewhat objectionable by the taste panel. Hanson (1960) has observed that the fragments of tough connective tissue (collagen) formed by preliminary grinding of meat for frankfurters remains essentially unchanged during chopping. A procedure for making frankfurters which would produce smaller particles of skin may reduce, or eliminate, the chewy pieces. Since decreasing the particle size also reduces the time necessary for collagen breakdown, (Lowe, 1955) some softening and mushiness may develop, especially when high temperatures (such as grilling or frying) and/or long times are used in heating for serving.

Juiciness. According to the results in Table 1, juiciness as perceived by the taste panel appeared to decrease as the skin level was increased, although seldom significantly. As measured by the percent expressible fluid, the juiciness showed a tendency to increase, although there was little correlation between these two measurements of juiciness (cold, r = .261; hot, r = .117). This is in agreement with Ritchey and Hostetler (1964), and Ritchey (1965), who also found no significant correlation between sensory juiciness scores and expressible fluid (in beef steaks). There was also little

correlation between percent skin and percent expressible fluid ($r = -.005$, cold, and $r = .047$, hot). There was, however, a highly significant negative correlation between percent skin and juiciness scores (cold, $r = -.755$; hot, $r = -.614$), indicating that the higher the amount of skin in a frankfurter the less juicy is the end product, and also that taste panel scores are a better indicator of juiciness in these frankfurters than is the Carver press method.

It appears from the results of this study that the high levels of skin in these frankfurters under the conditions of processing and heating for serving of this study did not make the frankfurters mushy; in fact, the opposite is true. However, since this apparent firmness is due, in part at least, to the chewy pieces of skin in the frankfurters, neither the addition of high levels of skin, nor the removal of all skin has produced the firm yet turgid texture associated with a good red meat frankfurter. These results do not rule out the possibility that the collagen in the connective tissue which is interspersed in the muscles of poultry, which was not apparent in the frankfurters as chewy pieces, is affecting adversely an emulsion made from these muscles. Maurer and Baker (1966) report the collagen content of poultry meat to range from an average of 0.9 percent for breast meat, 1.4 percent for thigh and back meat, 2.0 percent for wings and 2.3 percent for necks, to 2.4 percent for drumsticks, not including the skin on these parts. Hill (1966) reports the collagen content of the sternomandabularis (a neck muscle, which is known to contain a large amount of collagen in proportion to the rest of the carcass) of beef animals of various ages to range from 2.53 for 8–9 week old calves to 1.26 percent for older animals. This same muscle in pigs according to Hill contained 1.93 percent and in sheep 1.01 to 1.09 percent collagen. Other beef muscles which he analyzed include the longissimus dorsi, which contained 0.92 percent collagen, the psoas major, 0.62 percent to 0.39 percent, and the semitendinosus, 0.92 to 0.87 percent. In general, these figures appear considerably lower than those for poultry. It has been stated (Maurer and Baker, 1966) that collagen can be detrimental to the process of making poultry meat emulsions because of the inability of collagen to dissolve and form stabilizing membranes. Although the work that led to this conclusion was done on a model system, and not on sausage emulsions as such, it may in part explain why frankfurters made from red meat have a firmer texture than those made from poultry meat.

CONCLUSIONS

Addition of skin, under the conditions of this study, does not make franks "mushy" but in fact more chewy or firm. There is essentially no significant difference in any measurements of quality until the level of 20 percent skin is reached. This would indicate that the amount of skin normally present in boned-out chicken (about 15 percent added skin) makes little difference to the texture, according to the measurements of this study. Some other factors must be involved which cause the difference in texture between franks made from chicken alone and those made from red meat.

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The Response of Vitamin K Deficient Chicks Subjected to Heat Stress

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COMPARATIVELY little has been reported on the effect of environmental temperature on blood clotting or the prothrombin time of the chick. Rubenstein and Lack (1960) and Denyes and Carter (1961) reported prolonged prothrombin times in various species subjected to low temperatures. Mills *et al.* (1944) observed an increase in hemorrhagic deaths in vitamin K-deficient rats exposed to elevated temperatures. Griminger *et al.* (1963) subjected one year old adult Leghorn chickens of both sexes to high, normal and low temperatures. They observed a general trend toward hypoprothrombinemia with increasing environmental temperatures.

The present studies were conducted to determine the effect of dietary vitamin K on the prothrombin time of the chick when subjected to high environmental temperatures.

EXPERIMENTAL

Two experiments were conducted in a study of the effect of vitamin K and heat on chick prothrombin time. All chicks were brooded in electrically heated battery brooders provided with raised wire floors. Water and feed were provided *ad libitum*. The water troughs were cleaned daily. In experiment one, male broiler chicks thirty-five days of age were used. In experiment two, day old male broiler chicks were used. Ten chicks of approximately equal weight